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Recent Results of Symmetry Experiments in Gas-Filled Hohlraums at Nova using KPP Smoothed Beams

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Modeling and execution of radiation drive symmetry experiments in gas-filled hohlraums are being pursued to provide a better understanding of drive to predict target performance for the National Ignition Facility (NIF). These experiments have been performed in collaboration with LLNL, General Atomics, CEA, Physics International, and the University of Wisconsin on the Nova laser. The previous series of gas-filled hohlraum symmetry experiments at Nova with unsmoothed beams [N. Delamater, *et al., Physics of Plasmas*, 3, 2022, 1996] revealed a large unpredicted shift in imploded capsule symmetry and a significant movement in the laser beam position within the gas-filled hohlraums (about a 150 μm shift) from comparable vacuum hohlraum data. In recent experiments, kineform phase plates (KPP) to were used smooth all ten of Nova's beams to reduce laser beam steering hypothesized to be due to plasma flow and filamentation within the gas-filled hohlraum plasmas.

Several techniques were used to diagnose the radiation drive symmetry in the gas-filled hohlraum experiments. These methods include time-integrated and time-resolved techniques. The main time integrated symmetry measurement technique is imaging of the x-ray self emission from the imploded core of the capsule. The shape of the stagnated core gives a measure of the drive symmetry imposed on the capsule. The capsule was driven by a shaped laser pulse and has a convergence ratio (ratio of initial to final fuel diameter) of about 8. The capsule has been optimized to give a sensitive measure of drive symmetry avoiding problems with hydrodynamic instabilities and shell breakup that occur at high convergence. The time resolved measurements used thin wall hohlraums to directly image laser spot positions seen through the gold hohlraum wall in hard x-rays (>4 keV). The thin wall hohlraum allows simultaneous imaging of laser spots on the hohlraum wall and capsule implosion cores. The imaging of laser spots allows the direct measurement of any plasma induced beam steering. Diagnostics included time integrated and time resolved pinhole camera x-ray imagers which provide spatial resolution of about 6 μm and time resolution of 80 ps. Imaging diagnostics were used to view the capsule both along the hohlraum axis and perpendicular to it.

The Nova laser beams were aimed with an accuracy of 25 μm using precision pointing techniques. Precision power balance of the laser beams was maintained on all the shots, providing less than 5% rms variation among the ten beams at the peak of the pulse and less than 10% rms variation in the foot of the pulse. We performed a symmetry "tuning" experiment with various pointing conditions and hohlraum lengths to map out a symmetry scaling of imploded core shape vs. laser pointing for both methane-filled standard thick-walled and thin-wall hohlraums.

The results of the pointing scan recently obtained are given in Figure 1, which shows imploded capsule distortions as a function of laser pointing within the hohlraum. The figure also gives our previous results using unsmoothed non-KPP beams. New data was obtained at pointing 1125 µm, 1225 µm and 1325 µm. Note that at each of these pointings, the gas-filled hohlraum data with KPP smoothed laser beams is quite close to the vacuum hohlraum result, indicating an outward shift of the laser beams of only about 35 µm or less with gas-fills. Time resolved data of the laser beam position is consistent with this result. Figure 2 shows images of the laser spots at early times for vacuum and KPP smoothed lasers in gas-filled hohlraums. It can be seen that there is little difference apparent in the two cases.

We have found that KPP smoothed laser beams significantly reduce beam steering in gas-filled scale-1 hohlraums at Nova. There is a residual laser beam position shift of only 35 µm. These results are consistent with the hypothesis that filamentation with plasma flow was the cause of the beam deflection observed previously. Results from both implosions and laser spot imaging through thin walled hohlraums shows that beam steering is four times smaller than the unsmoothed beam results. Future work in symmetry will involve measurement and control of higher order modes using more NIF-like hohlraum and drive conditions.

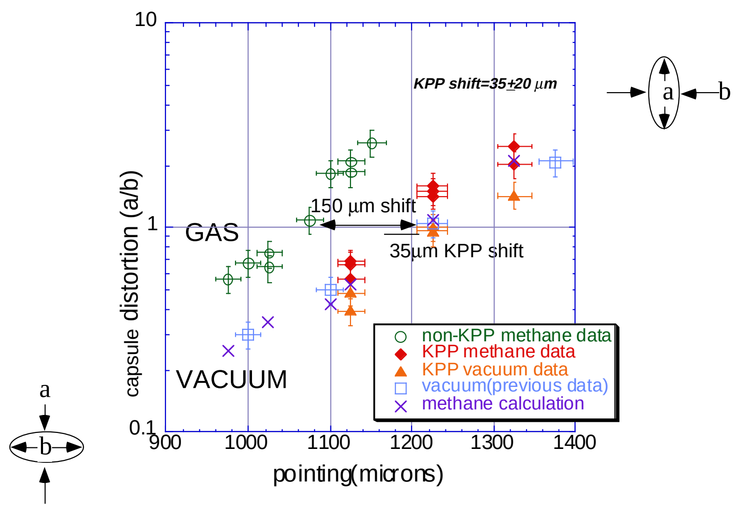

Figure 1. Pointing scan (distortion vs laser pointing) shows shift in gas with KPP is reduced to about 35µm

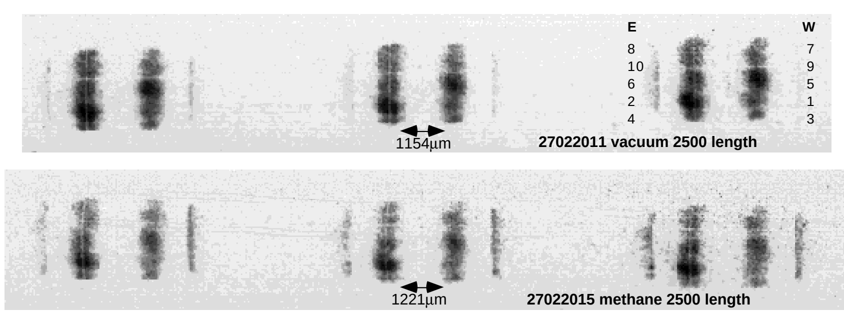

Figure 2. Laser spots seen through thin wall hohlraums for vacuum and gas-fills show only a small outward shift in gas.

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